made to do systematic work with these instruments, nor would it have been of the slightest use to employ them for anything but lecture-demonstrations. In 1728 or 1729 Jai Singh sent Figueredo, a Portuguese Jesuit, to Europe to procure astronomical tables, and he brought back "tables published under the name 'Lir,'" *i.e.* the tables of La Hire. Mr. Kaye also thinks that Jai Singh possessed the "Historia Cœlestis" of Flamsteed, and says (p. 69) that "he must have been acquainted with the teaching of Kepler, Galileo, and Newton, for he possessed the works of La Hire, Flamsteed, and others." But neither of these works could give the slightest clue to the teaching of European astronomers. The "Historia Cœlestis" contains Flamsteed's observations and the resulting star-catalogue (as well as reprints of previous catalogues), and La Hire's planetary tables are not founded on any theory, but were constructed in an empirical manner, as to the details of which nothing is known. Mr. Kaye suggests (p. 90) that as Jai Singh's European advisers were chiefly Roman Catholic priests, the development of astronomy since Copernicus must have been discredited in his eyes. This suggestion is of course quite unwarranted, as there were plenty of priests in those days who did good work in astronomy.

J. L. E. DREYER.

THE OCCLUSION OF GASES BY METALS.

PRESIDING at the meeting of the Faraday Society in November last, at which the subject of the occlusion of gases by metals was discussed, Sir Robert Hadfield delivered an introductory address, which is about to be published by the society with an account of the discussion. It appears from the bibliography attached to this address that Thomas Graham was one of the first to investigate this subject. His results were published in the Philosophical Transactions of the Royal Society in 1867, the title of the paper being "The Occlusion of Gases by Meteoric Iron." The particular specimen investigated contained 90·9 per cent. of iron, 8·45 per cent. of nickel, and a small quantity of cobalt. It was free from any stony admixture, and was remarkably pure and malleable. A strip cut from this with a clean chisel was first well washed with a hot solution of potash, then with distilled water, and afterwards dried. It was then placed in a porcelain tube which was evacuated and afterwards heated to redness in a combustion furnace.

Gas was observed to come off freely, and was collected in successive portions. The first portion evolved consisted principally of hydrogen. Succeeding portions also contained hydrogen as the chief constituent, with smaller quantities of carbonic oxide and nitrogen. This particular specimen of iron yielded 2·8 times its own volume of gas. Graham also investigated the gas taken up by iron from a carbonaceous fire, and in the case of some clean horseshoe nails which he heated in a similar way he found that the metal yielded 2·66 times its own volume of gas, containing about 50 per cent. of carbonic oxide, 35 per cent. of hydrogen, 7·7 per cent. of carbon dioxide, and 7 per cent. of nitrogen. He concluded that as hydrogen was recognised in the spectrum analysis of the lights of the fixed stars, the Lenarto meteoric iron which he had investigated came from an atmosphere in which hydrogen was the chief constituent, and that it held imprisoned within it the hydrogen of the stars.

The latest investigations on the subject of "Occluded Gases in Ferrous Alloys" are those by Allemann and Darlington, whose results are published in the proceedings of the Franklin Institute of Philadelphia in February, March, and April of 1918. These investigators describe a gas-tight vacuum furnace which they have constructed capable of continuous service at temperatures of approximately 1900° C. By means of this they claim that all the gases occluded by ferrous alloys may be removed and collected. They have found that hydrogen is most readily set free, that carbon monoxide comes next, and that nitrogen appears to be held the most tenaciously. As yet they have been unable to determine whether the presence of oxygen in their gases is due to the decomposition of the various oxides of iron or the dissociation of one of the oxides of carbon. Allemann and Darlington have found that ferrous alloys may occlude relatively large volumes of gases, in some cases equal to 200 times the volume of the metal, and they suggest that, in addition to the ordinary functions of metals, aluminium, silicon, manganese, titanium, and tungsten, when added to molten iron alloys, may either prevent the occlusion of large quantities of gases or aid in eliminating such gases at lower temperatures than those at which such elimination ordinarily occurs. Finally, they have shown that the removal of these gases markedly changes the microstructure and increases the density of the alloys.

Sir Robert Hadfield then proceeds to consider the bearing of scientific work of the foregoing kind on the problem of obtaining sound steel, and quotes at some length the views of the late Dr. Héroult as set forth in his paper on "The Presence and Influences of Gases in Steel." Héroult pointed out that the gases obtained from blowholes in unsound steel ingots always contain hydrogen and nitrogen, often with only traces of carbon monoxide, but it is well known that sound steel, when heated *in vacuo*, also gives off these gases. It has also been shown that the quantities of gases so liberated are about the same, whether the steel be made by the crucible, the Bessemer, the open hearth, or the electric furnace. In consequence of this he concluded that hydrogen and nitrogen are not the cause of the production of blowholes, but that the latter are the result of the liberation of carbon monoxide, except in the case of blowholes near the surface, which are due to the poor condition of the moulds. Héroult's view of the production of blowholes was as follows:—

The carbon monoxide does not pre-exist in the

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steel. It is produced only when the latter cools down and has partly solidified. Steel that will produce blowholes contains in the molten condition dissolved carbon and oxygen, and for each temperature and composition there is a particular equilibrium at which no chemical reaction takes place. The heat is then what is called "dead-melted." If, on one hand, the temperature is raised, the reducing action of the carbon is intensified, and carbon monoxide will be evolved; if, on the other, the temperature is lowered, nothing happens until the steel has partially solidified. This causes an increased concentration of carbon and oxygen in the still liquid portion, as a result of which carbon monoxide is evolved. This gas is unable to escape, and by its pressure produces the blowholes. On cooling, it is gradually absorbed by the now solid metal.

As yet almost nothing is known as to the condition in which these gases exist in metals and alloys. Prof. McBain pointed out in his contribution to the discussion that the occlusion of gases by metals comprises processes which are special instances of the general group of different phenomena known collectively as "sorption," and that in the vast majority of cases the intermingling phenomena have not been disentangled or even experimentally identified. It is necessary to take into consideration true adsorption (surface condensation), true absorption (true solution in a solid), and chemical reactions that may ensue.

Sir Robert Hadfield finally considers briefly the methods which have been found effective in producing sound steel. As he points out, great difficulties were experienced in the early days of making steel castings in producing sound metal. The very useful element silicon was scarcely obtainable except in combinations which caused as much trouble as the unsoundness itself. High-percentage ferro-silicons with low carbon and silico-speigels were unknown. Manganese, though useful, was only a partial cure, and aluminium as a commercial metal had not yet arrived.

It appears that it was three French metallurgists who introduced and perfected the successful production of ferro-alloys containing high percentages of silicon and also manganese, as a result of which the manufacture of sound steel by commercial processes on a large scale was rendered possible. These men were MM. Euverte, Pourcel, and Gautier, of the Terre Noire Works. Credit should also be given to Hall in America and Héroult in France, who were the pioneers of the production of aluminium on a commercial scale. This element is now one of the most valuable available for the prevention of blowholes in steel. As an instance of the successful production of sound steel castings at the present day Sir Robert Hadfield gives some details of the casting of hydraulic cylinders for cotton baling presses. These cylinders have no mechanical work done upon them, but are used in the cast state. They may run up to a length of 30 ft. The ram measures from 7 in. to 9 in. in diameter. The walls of the cylinders seldom exceed 2¼ in. in thickness, and have to stand the hydraulic test pressure of 4 tons per sq. in. The steel is cast at a temperature of about 1540° C., and is poured into sand moulds which are liable to give off gases. Its contraction is slightly more than 0·25 in. per ft., so that the mould is not less than 7 in. longer than the cylinder itself when cooled down. Below 1500° C. the steel quickly loses its fluidity, and not many degrees lower it is quite pasty. The fact that, in spite of the difficulty of meeting these conditions, satisfactory cylinders can be made indicates that the art of steel casting has reached a high stage of technical perfection. H. C. H. C.

PROF. J. J. T. SCHLŒSING.

AGRICULTURAL investigators in all countries will learn with regret of the death of Prof. Jean Jacques Théophile Schlœsing at Paris on February 8. Although Prof. Schlœsing had attained the advanced age of ninety-four, his vigour and mental alertness were unusually good, and he had had the satisfaction of seeing his son continuing in his own branch of science, doing work of great importance, and making a reputation scarcely less distinguished than his own.

Schlœsing was born at Marseilles on July 9, 1824; he entered the Polytechnic in 1841, and was appointed director of the Ecole des Tabacs in 1846. There he began an important series of analytical investigations the purpose of which was to improve the method of detecting and estimating the common constituents of soils and plants, such as potassium, ammonium, nitric, phosphoric, and hydrochloric acids, and the common organic acids, such as acetic, tartaric, citric, oxalic, malic, and others. The current methods of dealing with natural products were sometimes exceedingly laborious, and lacked even the merit of accuracy; the determinations of ammonia in rain-water made with all possible care by Lawes and Gilbert in 1853 had involved the distillation of 2 cwt. of rain and evaporation of the distillate with sulphuric acid; even then the results came out something like 100 per cent. too high. It is impossible, therefore, to over-estimate the value of careful analytical investigations such as those made by Schlœsing.

His next important series of investigations was on the soil. By a lengthy washing process he obtained a preparation of the finest clay particles which remained indefinitely suspended in pure water, but could be precipitated by traces of a calcium or magnesium salt. This was commonly regarded as being in some sense the essential clay, and agricultural chemists marvelled at the minute amount present even in heavy soils. The conception served a useful purpose, but it has now been replaced by a broader one: the soil is now considered to be made up of particles varying from 1 mm. downwards to molecular dimensions, the different groups merging one into another without perceptible breaks. The clay group is assigned for convenience an upper limit of 0·002 mm., but this is regarded as purely conventional.

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